Preprint
UCRL-JC-146948

National Ignition Facility End-to-End Beamline Optical Model

R.J. Korniski, J.K. Lawson

This article was submitted to International Optical Design Conference, Tucson, Arizona, June 3-7, 2002

January 29, 2002

U.S. Department of Energy
Lawrence Livermore National Laboratory

National Ignition Facility end-to-end beamline optical model

Ronald J. Korniski
Science Applications International Corporation, 9455 Towne Centre Dr., MS W-2, San Diego, California 92121
805 241-4281, 805 241-7195 fax, korniskir@saic.com

Janice K. Lawson
Lawrence Livermore National Laboratory, 7000 East Avenue, L-470, Livermore, CA 94551
925 423-2075, 925 422-4667 fax, lawson3@llnl.gov

Abstract: The optical model of a National Ignition Facility beamline will be described and illustrated. The complexity of the optical design will be evident. The benefits of having an End-to-End optical model will be presented.

OCIS codes: (140.0140) Lasers and laser optics; (120.4820) Optical Systems

Introduction

The National Ignition Facility is a high-power solid-state laser facility being built to satisfy a wide array of user requirements. During the design process, system requirements were developed to meet the user needs. Optics were designed to meet a hierarchy of subsystem and system requirements. An integrated beamline optical model on lens design software has been developed that can verify that the optical design meets the system requirements.

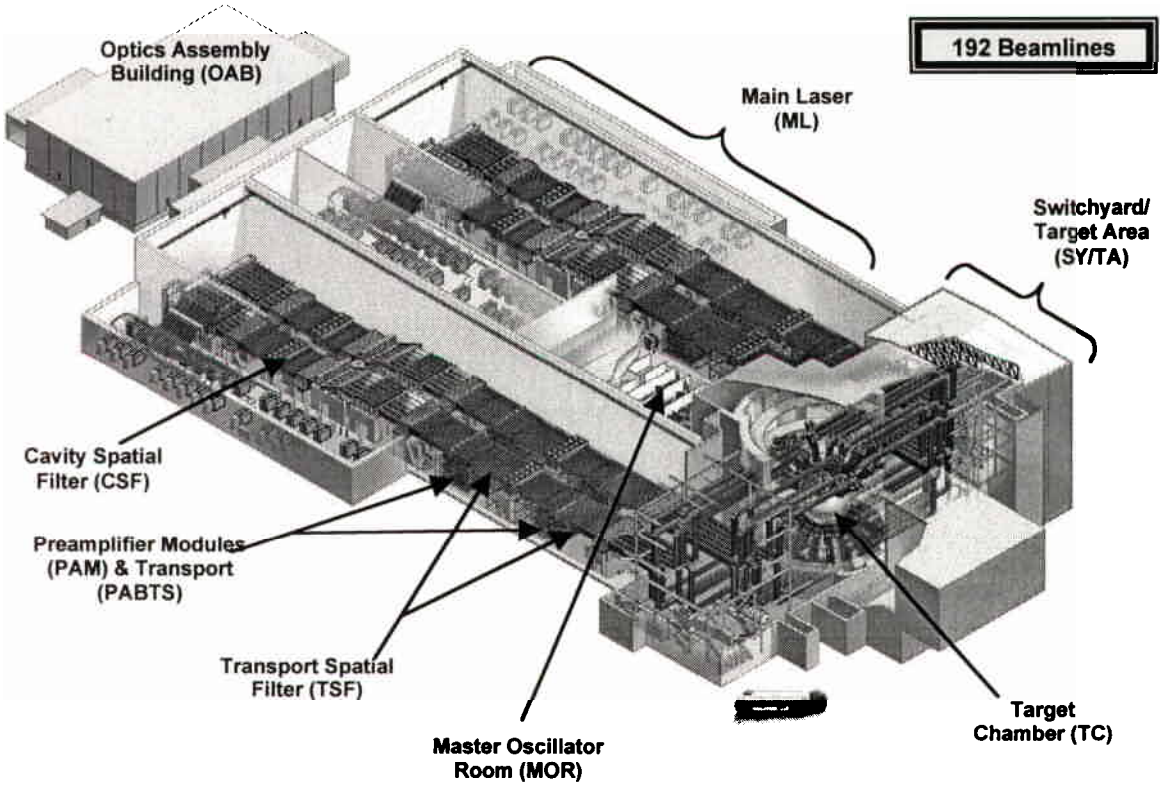

Fig. 1. Annotated view of National Ignition Facility

End-to-End Optical Model Design Overview

An End-to-End optical model of a NIF beamline has been developed from the individual optical configuration drawings of the subsystems and element drawings. The annotated computer-generated beamline drawing below illustrates that vast distances the beamline covers relative to the apertures (Main Laser lenses are about 410x410mm).

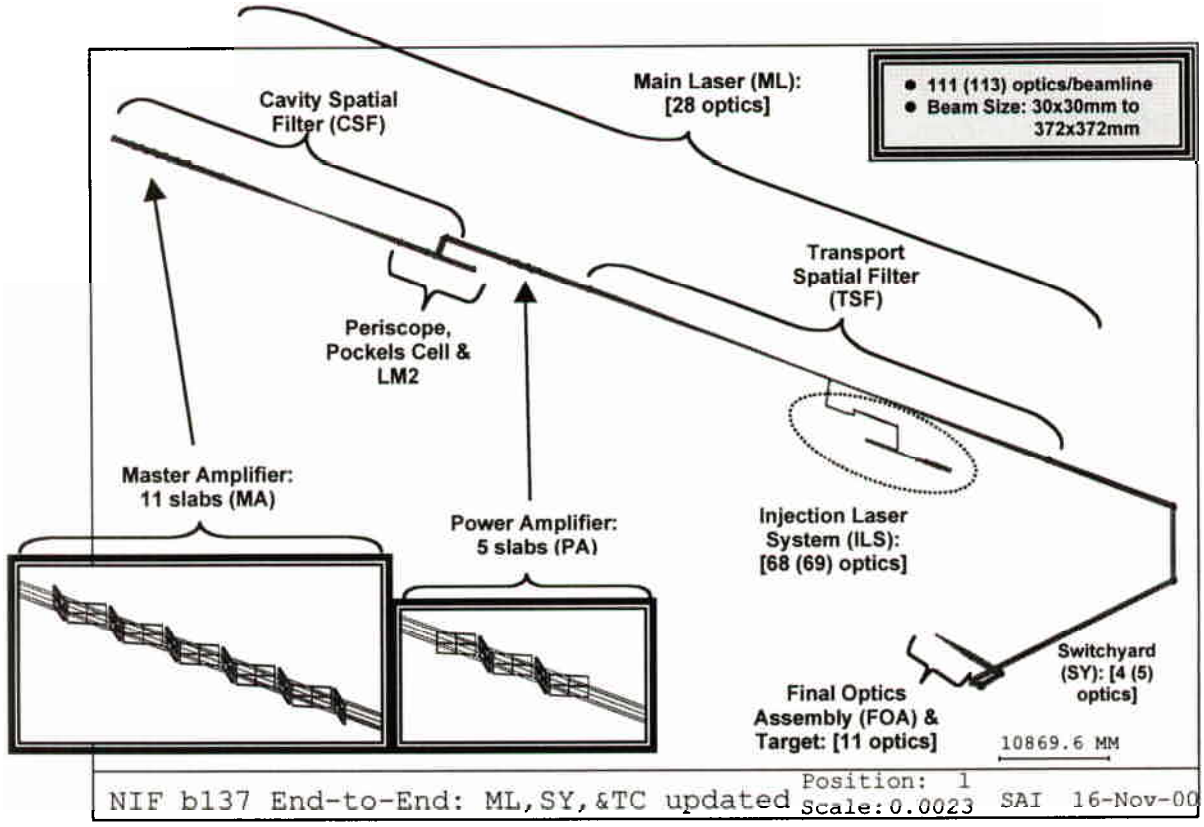

Fig. 2. Annotated plot of a beamline

The optical model consists of over 500 surfaces positioned in both local and global coordinate systems. Other salient modeling parameters are quantified in the table below. This model is a large database, but only one of 192.

Table 1. Optical model parameter summary

Current NIF End-to-End Optical Model Details				
Beamline	Cluster 1, Bundle 3, Beam 7		Lines of code	>2600
Model types	Near field & Far Field		Position definitions	Relative & Global (5 global ones used)
Subsystems	8		Pickups	>438
Surfaces	>525		Aperture specifications	>793 (OCAs: >236, Mechanical edges >557
Surface types	4: flat spherical conic, bilaterally symmetric asphere		Wavelength	1053nm (frequency doubling & tripling modeled as adjusted refractive index)

The End-to-End optical model is being used to validate the flow-down assumptions mentioned above. Many optical and mechanical design aspects of the NIF beamline(s) can be explored with this type of modeling. Some total beamline characteristics that can be analyzed with such a beamline model, but not limited to, are as follows.

1. Pupil imaging (location, magnification, and aberrations; see Relay Plane presentation for more information)
2. Total nominal beam wavefront error and geometrical spot size
3. Focus location relative to a global design coordinate reference
4. Real-ray paths
5. Optical clear apertures
6. Mechanical design checks
7. Pointing and centering needs
8. Alignment sensitivities
9. Total system tolerance analyses

Additional Optical Models Considered

One accurate and up-to-date NIF beamline optical model has proved to be invaluable. We are currently working to expand this single model into a suite of models sufficient to address optical issues that arise. Though most of the components are identical on each of the beamlines, the geometry varies from beamline to beamline to distribute 192 amplified beamlines spherically around the target. Other beamline optical models will be constructed as required to validate the mechanical model and address optical issues.

Identified beamline uniqueness sources (occurrences), both mechanical and optical:

- Switchyard (192)
- Main Laser Diagnostic Beamsplitter (2)
- Transport Spatial Filter [TSF] Lenses SF3 & SF4 (2)
- Main Laser Periscope (4)
- Injection Lens Window (4)
- Preamplifier Beam Transport System [PABTS]/Injection System [INJSYS] paths
  - Injection feed to TSF (2)
  - 1:4 beam split (4)
- Injection Laser System aiming (2)
- PABTS vacuum relay telescope [VRT] (4-7)
- PABTS trombone timing (192)

Summary

The current End-to-End NIF beamline optical model is a living one. Revisions to the beamline database is ongoing both from mechanical and optical considerations. To date the End-to-End optical model has been used to verify the following aspects of a NIF beamline.

- Impact on critical clear apertures in the Master Amplifier for pupil location variation
- Main Laser tilt adjustments to achieve Pointing and Centering from nominal subsystem positioning and ramifications of Injection Laser System positioning
- Definition and location of the last pupil (relayed aperture plane, see Relay Plane presentation for more information on this complex issue)
- Switchyard mirror orientations
- Focus on target and final wavefront error
- Conjugate location of Deformable Mirror (LM1) in the Injection Laser System
- Exiting beam characteristics from the Main Laser into the Switchyard (intercepts and angular)
- Beam residual deflection of "compensated" wedged optical components

Various other evaluations are planned and more are coming to light.

This work was performed under the auspices of the U. S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under Contract No. W-7405-Eng-48.